TRANSMISSION MEASUREMENTS INVOLVING CARRIER MULTIPLEX EQUIPMENT

CONTENTS

1. GENERAL
2. IMPORTANT MINIMUM CHARACTERISTICS OF TEST EQUIPMENT FOR MAKING CARRIER MULTIPLEX MEASUREMENTS
3. HOW TO MAKE VOICE FREQUENCY INSERTION LOSS MEASUREMENTS ON CARRIER CHANNELS
4. HOW TO MAKE ECHO RETURN LOSS AND SINGING POINT MEASUREMENTS ON CARRIER CHANNELS
5. HOW TO MAKE IDLE CHANNEL NOISE MEASUREMENTS ON CARRIER CHANNELS
6. HOW TO MAKE IMPULSE NOISE MEASUREMENTS ON CARRIER CHANNELS
7. HOW TO MAKE PULSE SIGNALING MEASUREMENTS ON CARRIER CHANNELS
8. HOW TO MAKE INSERTION LOSS MEASUREMENTS AT CARRIER FREQUENCIES
9. HOW TO MAKE CARRIER FREQUENCY CROSSTALK LOSS MEASUREMENTS ON OPEN WIRE AND CABLE

APPENDIX A - TERMINOLOGY

FIGURE 1 - VOICE FREQUENCY INSERTION LOSS MEASUREMENTS ON CARRIER CHANNELS
FIGURE 2 - DRAWING OF TEST HYBRID TERMINALS
FIGURE 3 - ECHO RETURN LOSS MEASUREMENTS ON CARRIER CHANNELS
FIGURE 4 - SINGING POINT MEASUREMENTS ON CARRIER CHANNELS
FIGURE 5 - IDLE CHANNEL NOISE MEASUREMENTS ON CARRIER CHANNELS
FIGURE 6 - IMPULSE NOISE MEASUREMENTS ON CARRIER CHANNELS
FIGURE 7 - PULSE SIGNALING MEASUREMENTS ON CARRIER CHANNELS
FIGURE 8 - CARRIER FREQUENCY INSERTION LOSS ON OPEN WIRE
FIGURE 9 - CARRIER FREQUENCY INSERTION LOSS ON CABLE
FIGURE 10 - CARRIER FREQUENCY CROSSTALK LOSS MEASUREMENTS ON OPEN WIRE
FIGURE 11 - CARRIER FREQUENCY CROSSTALK LOSS MEASUREMENTS ON CABLE

1. GENERAL

1.1 This section is intended to provide REA borrowers, consulting engineers, contractors, and other interested parties with technical information for use in making measurements on carrier multiplex equipment and on wire and cable at carrier frequencies.

1.2 The measurement procedures described in paragraphs 3-7 apply to all types of carrier multiplex equipment whether it is to be used on wire plant or on radio. Repeating coils are used in voice frequency (vf) measurements to insure balance, provide d.c. isolation and for impedance matching to eliminate the need for meter correction factors.

1.3 This section is arranged in short paragraphs, each covering one or two types of measurements. After reviewing the section one time, it will not be necessary to later review the entire section for a particular type of measurement. Instead, refer to the paragraph and figures dealing with that measurement only.

1.4 Paragraph 2 lists the instruments necessary to make the following measurements and some of their more important characteristics. The characteristics listed are based primarily on equipment that is currently available at a reasonable price. The characteristics should be geared to the particular needs of an organization, keeping the present and future requirements in mind. Some instruments are multipurpose in their use. For example, a noise measuring set with flat weighting can also be used as a voice frequency voltmeter. The instruments listed are not limited to carrier measurements, but may be used for voice frequency measurements and general maintenance also. New developments in both carrier and instruments may alter instrument requirements in the future.

1.5 Paragraphs 3-6 give procedures for making voice frequency measurements on carrier channels. Voice frequency measurements of carrier channels are performed in much the same way as on any two-wire physical circuit at voice frequencies. Access to the carrier two-wire drop, seizure of the channel (signaling), and signal level of the oscillator or noise generator become important factors in the measurements. After proper attention is given to these factors, the carrier channel can be treated as a two-wire physical vf circuit.

1.51 Voice frequency insertion loss and idle channel noise measurements are the most common measurements on carrier channels for initial alignment and maintenance. On toll connecting trunks, proper terminal impedance and carrier hybrid balance are important. Measurements relating to impedance and balance are called echo return loss and singing point and are normally measured from the toll center looking toward the end offices. However, on occasion, these measurements are made at points other than toll centers. Data transmission is expected to be used extensively in the future and as a result impulse noise measurements will become very important.

1.52 When making measurements on carrier channels equipped with loop dial signaling (one way), the method of seizure may vary somewhat. All that is necessary to seize the outgoing (originating) loop dial is to provide a d.c. path (repeating coils, etc.) across the carrier two-wire drop. To seize a channel with incoming (terminating) loop dial, rely on the instructions of the carrier equipment manufacturer. The purpose of seizing incoming loop dial signaling is to provide reverse battery supervision at the originating terminal and to remove (or shift) the signaling tone. For measurement purposes, reversing battery is not generally important; however, removing the signaling tone may be important, especially on noise measurements.

1.53 Some instruments use a holding coil to seize outgoing loop dial and subscriber carrier equipment. Some of the new types of subscriber carrier are designed to be located next to the telephone set and deliver less current than conventional subscriber carrier. The resistance of the holding coil may not be low enough to seize these new types of subscriber carrier. In this situation a repeating coil must be used for seizing.

1.6 Paragraph 7 indicates how to make pulse signaling measurements on carrier channels. Pulsing is not generally considered a part of transmission. However, a carrier channel converts the d.c. pulsing into a.c. signaling which is directly related to transmission.

1.7 Paragraphs 8 and 9 tell how to measure the physical wire and cable to which carrier may be applied. Insertion loss measurements at carrier frequencies are very similar to those at voice frequencies. Losses at carrier frequencies are usually high, so a tuned voltmeter or frequency selective voltmeter is usually required to reject the unwanted signals. Crosstalk loss measurements as described in paragraph 9 become important if more than one carrier system is planned on the same open wire route or in the same cable.

1.8 Many of the measurements described in this section can be made using a procedure called loop around testing. This eliminates the necessity for having a second man at a remote office to send tones or provide terminations. Loop around testing reduces the number of measurement personnel required and in turn reduces operating expenses.

1.81 To provide for loop around testing, the office must be equipped with a special test set that is assigned two test numbers. Upon dialing one number, a tone (or tones in sequence) is sent back at a level of zero dbm (unless otherwise specified). The other test number is assigned to a balance (or quiet termination (i.e., 900 ohms in series with 2 mfd.). A third type of test can be made by simultaneously dialing the two test numbers on separate lines; this connects the two connector terminals together in the central office and provides a loop back to the calling end. The calling end may be at a subscriber location or another central office.

1.82 Using the above method to dial a balance termination, <u>one man</u> can make idle channel noise, echo return loss, and singing point measurements at the dialing end of the system.

1.83 By dialing the number for the test tone, the carrier channel net loss can be determined in one direction. Follow the instructions of the manufacturer of the loop around test equipment for more detailed instructions.

2. IMPORTANT MINIMUM CHARACTERISTICS OF TEST EQUIPMENT FOR MAKING CARRIER MULTIPLEX MEASUREMENTS

2.01 Oscillator

(a) Output Impedance: 600 ohms ± 5%
(b) Output Level: variable to +10 dbm maximum
(c) Frequency Range: 10 Hz to 500 kHz
(d) Frequency Accuracy: ± 2% of dial
(e) Distortion: 1% maximum, under any load conditions
(f) Stability of frequency and level
(g) Suggested Method of Powering: rechargeable battery

2.02 A.C. Voltmeter

(a) Input Impedance: at least 20,000 ohms
(b) Frequency Range: 10 Hz to 500 kHz
(c) Measuring Level: 0.001 to 300 volts, full scale
(d) Measuring Accuracy: ± 3% maximum error
(e) Calibrated: in volts and dbm in terms of 600 ohms
(f) Suggest Method of Powering: rechargeable battery

2.03 Frequency Selective Voltmeter (FSVM)

(a) Input Impedance: at least 5000 ohms
(b) Frequency Range: 10 kHz to 500 kHz (determined primarily by frequencies of carrier system)
(c) Frequency Accuracy: ± 3 kHz
(d) Measuring Level: +20 dbm to -60 dbm, full scale
(e) Measuring Accuracy: ± 1 db
(f) Suggest Method of Powering: rechargeable battery

2.04 Noise Measuring Set (NMS)

(a) Weighting: C-Message (plus others as required for other applications)
(b) Measuring Level: 0 to 90 dbrnc
(c) Measuring Accuracy: ± 1 db
(d) Functions: Noise to Ground
Noise Metallic, 600 ohms terminated
Noise Metallic, 900 ohms terminated
Noise Metallic (600 and/or 900 ohms), Bridging
(e) Input Impedance: Noise to Ground: T to R = 40,000 ohms
T + R to Ground = 100,000 ohms
Noise Metallic, 600 ohms = 600 ohms
Noise Metallic, 900 ohms = 900 ohms
Noise Metallic, Bridging = At least 5000 ohms

2.05 Noise Generator (NG)

(a) Generates random noise throughout the vf spectrum
(b) Output Impedance: 600 ohms
(c) Output Level: variable to +10 dbm maximum
(d) Weighting: 455 B (plus others as required for other applications)

2.06 Singing Point Test Set (SPTS)

(a) The SPTS consists of an amplifier, attenuator, low-pass filter, high pass filter, and poling switch.
(b) The amplifier and attenuator are arranged as a variable gain amplifier. The amplifier should have at least 40 db gain at 1000 Hz.
(c) The response of the SPTS with filters should be equivalent to the Northeast Electronics Corporation TTS 12A or -6 db at 300 and 3400 Hz, relative to 1000 Hz.

2.07 Impulse Noise Counter (See paragraph 6)

2.08 Pulsing Test Set

(a) Must generate and measure pulses over a range of at least 8 to 12 pulses per second (pps) and at least 30% to 70% break.
(b) Accuracy: ± 2%
(c) Must adapt to all types of signaling the user is likely to encounter, especially E & M and Loop Dial.

2.09 Carrier Frequency Repeating Coil (cf coil)

(a) Impedance Ratios (ohms): 600:600 (or 135:135), 600:135
(b) Insertion Loss: approximately 0.2 db
(c) Must have good balance if used with unbalanced equipment
Examples: Lynch 2624, Lynch 2692, Hewlett-Packard AC-60A

2.10 Voice Frequency Repeating Coil (vf coil)

(a) Impedance Ratios (ohms): 600:600, 600:900
(b) Insertion Loss: approximately 0.5 db
(c) Must have good balance if used with unbalanced equipment
Example: Altec 15192 line transformer. Other suitable vf repeating coils for making measurements are Western Electric 120H (600:600 ohms), Western Electric 120J (600:900 ohms), Automatic Electric 1200H (600:600 ohms) and Automatic Electric 1200J (600:900 ohms). However, these do not have both impedance ratios in the same coil.

2.11 Test Hybrid

(a) Impedance Ratio: 600:900 ohms or 600:600 ohms
(b) Balance: At least 45 db, line vs. network
(c) Insertion Loss: 3.5 to 4 db (two-wire to four-wire)

(d) Must withstand 120 ma. d.c. out-of-balance current without upsetting the balance if it is used to seize the circuit.

2.12 Terminations: 600 ohm ± 1% resistor*
900 ohm ± 1% resistor
110 (or 135) ohm ± 1% resistor*
2.0 mfd. ± 5% capacitor

*Resistors must be noninductive if used for carrier frequency measurements.

3. HOW TO MAKE VOICE FREQUENCY INSERTION LOSS MEASUREMENTS ON CARRIER CHANNELS

3.1 General

3.11 Voice frequency insertion loss measurements of carrier channels are performed in much the same way as insertion loss on any two-wire physical circuit at voice frequencies.

3.2 Access

3.21 Access both ends of the carrier equipment at the two-wire drop so that the central office equipment is disconnected at this point. Test jacks may be available for this purpose.

3.3 Seizing the Channel

3.31 The carrier channel must be seized (at both ends) in its normal manner to place the channel in a normal operating (talking) condition. The method of seizure will depend on the type of signaling employed. Seizure of the channel will remove the signaling tone or shift it to another frequency.

3.32 E & M: To seize a channel with E & M signaling, simply apply -48 volts d.c. (fused) to each terminal "M" lead.

3.33 Outgoing Loop Dial: The vf repeating coils used in the measurements provide a d.c. path to seize the channel.

3.34 Incoming Loop Dial: See paragraph 1.52.

3.35 Subscriber Carrier: On the subscriber end, the vf repeating coil provides a d.c. path to seize that end. There is no seizure technique for the CO terminal.

3.4 Measurement

3.41 Calibrate the oscillator for the carrier manufacturer's recommended test tone level (generally zero dbm) as shown in Figure 1A. This calibration includes the loss of the vf repeating coils at the sending and receiving ends (approximately 0.5 db per coil 300 Hz and up).

3.42 Connect the oscillator (through one vf coil) to the carrier drop at one terminal end as shown in Figure 1B. Also connect the voltmeter to the receiving (distant) end as shown.

3.43 Record the sending level of the oscillator and the receiving level on the voltmeter. The insertion loss is the difference of the two levels.

Example 1. Oscillator is calibrated for a sending level of 0 dbm. The voltmeter is receiving -3.8 dbm. The difference of the two readings is: 0 - (-3.8) = 3.8 db; thus, the insertion loss is 3.8 db.

3.44 VF insertion loss measurements should be made at 1000 Hz and at various other frequencies throughout the voice range. If the carrier has Inband Signaling, (i.e., 2600 Hz) the frequency response cannot be accurately determined without using special techniques. Using single tones to make frequency response measurements will show a severe slot in the response around the signaling frequency (i.e., 2600 Hz). In an actual talking condition, this slot is not present due to guard circuits in the signaling units. This is generally a laboratory measurement not usually performed in the field.

3.45 If the carrier is equipped with compandors or other noise reducing devices, the manufacturer may recommend special techniques for measuring frequency response to avoid erroneous readings.

Example 2. A carrier manufacturer claims a frequency response of +1 db to -3 db from 250 Hz to 3200 Hz relative to 1000 Hz. Enough frequencies should be measured to verify this; also, there should be no gain peaks in excess of 1.0 db (relative to 1000 Hz) at any frequency to comply with REA specifications.

3.5 Terminal Impedance

3.51 In the preceding measurements it has been assumed that the drop impedance of the carrier is 900 ohms. This is the case in the majority of REA-financed systems (toll connecting trunks at Class 5 office; EAS trunks; and subscriber carrier). However, in some cases the carrier drop impedance may be 600 ohms (toll connecting trunks at Class 4 office).

3.52 If one terminal is 900 ohms and the other is 600 ohms, the calibration should still be made as shown in Figure 1A. The measurement is now performed as shown in Figure 1C. The calibration and measurement performed in this manner assumes that the 600:600 ohm ratio coil has the same insertion loss as the 600:900 ohm ratio coil. Using the Altec 15192 Line Transformer (vf coil), or equivalent, the loss is the same using either impedance ratio.

4. HOW TO MAKE ECHO RETURN LOSS AND SINGING POINT MEASUREMENTS ON CARRIER CHANNELS

4.1 General

4.11 Echo Return Loss (ERL) and Singing Point (SP) measurements are made from the toll center (Class 4 office) on toll connecting trunks terminating at the end office (Class 5). This would indicate that the measurements would always be made at a 600 ohm office. However, where carrier equipment is used to make up only part of the toll connecting trunk, both ends of it may have 900 ohm terminals. To insure that carrier equipment in this application does not degrade the overall toll connecting trunk, ERL and SP measurements are sometimes made on 900 ohm equipment.

4.12 The following procedure gives the method for measuring ERL and SP of the carrier terminal only; it may be necessary to follow a similar procedure to include the central office equipment.

4.2 Access

4.21 Access both ends of the carrier equipment at the two-wire drop so that the central office equipment is disconnected at this point.

4.3 Seizing the Channel

4.31 The carrier channel must be seized at both ends to place the channel in a normal operating (talking) condition. The method of seizure will depend on the type of signaling employed. Seizure of the channel will remove the signaling tone or shift it to another frequency.

4.32 E & M: To seize a channel with E & M signaling, simply apply -48 volts d.c. (fused) to each terminal "M" lead. It is almost assured that E & M signaling will be used at the toll center on toll connecting trunks, However, in some cases, the toll connecting carrier may use loop dial signaling.

4.33 Outgoing Loop Dial: The hybrid used in making ERL and SP measurements must (1) have a d.c. path at the line terminals to seize the channel and (2) not become unbalanced (line vs. network) when this d.c. current flows in the line side of the hybrid. When the outgoing loop dial end is to be terminated rather than measured, place a repeating coil in tandem with the termination or place a high impedance holding coil (i.e., central office battery feed relay) in parallel with the termination.

4.34 Incoming Loop Dial: See paragraph 1.52.

4.4 ERL Measurement

4.41 Preliminary Calibration: When making ERL measurements, the signal level at the carrier two-wire drop should be approximately equal to the manufacturer's recommended test tone level. Zero dbm is approximately equal to 90 dbrnc of noise. The average coil hybrid exhibits about 7 db loss from the oscillator terminals to the voltmeter terminals. Therefore, for zero dbm at the carrier terminals the noise generator should be set for approximately +4 dbm output (455B weighted). As shown in Figure 3A, this will be approximately +0.5 dbm at the line terminals of the hybrid.

4.42 ERL Reference: In making ERL measurements, the first measurement is a reference. This takes into account the loss of the test hybrid. When making many ERL measurements, the reference is taken initially and checked from time to time. It is not necessary to take a reference for each ERL measurement.

4.43 Referring to Figure 3B, record the reading on the noise measuring set (NMS) (600 ohm N_m, C-Message weighted) with the hybrid line terminals open and again with the line terminals shorted. The average of the two readings is the reference.

Example 1. With the line terminals open, the NMS reads 88 dbrnc and shorted reads 86 dbrnc. The reference is: $\frac{88 + 86}{2} = 87$ dbrnc.

4.44 ERL Measure: Connect the test hybrid line terminals to the carrier two-wire terminals at the toll center (Figure 3C). Terminate the distant office with 900 ohms in series with 2 mfd. Record the reading on the NMS. The reference (paragraph 4.43) minus this reading is the ERL in db.

Example 2. Suppose the NMS reading ERL measured in paragraph 4.44 was 59 dbrnc. With the reference of 87 dbrnc used in Example 1, ERL = 87 - 59 = 28 db.

4.5 SP Measurement

4.51 Test Hybrid Loss: To make SP measurements, it is first necessary to determine the loss of the test hybrid. Apply 1000 Hz at zero dbm or other convenient level at the hybrid oscillator terminals (Figure 4A). With the line terminals open, record the difference between the applied signal level and the reading on the voltmeter; again record the difference with the line terminals shorted. The average of the two readings is considered to be the hybrid loss.

4.52 SPTS Calibrate: Set gain dials on singing point test set (SPTS) to zero. Apply 1000 Hz at zero dbm to input of SPTS (Figure 4B). Adjust the calibration adjustment for zero dbm on the voltmeter. The SPTS should contain low pass and high pass filters. If not, an external filter must be applied as shown in Figure 4C. In either case, the loss of the filter(s) is included in the calibration.

4.53 SP Measure: Connect the SPTS to the test hybrid oscillator and voltmeter terminals as shown in Figure 4D. Monitor the SPTS (at the monitor jack) with headphones.

4.54 Increase SPTS gain in 10 db steps until singing occurs. Reduce the gain by 10 db and increase the gain in 1 db steps. Record the gain setting at the lowest point that sustained singing occurs.

4.55 Reverse the poling switch and repeat procedure in paragraph 4.54.

4.56 Singing Point: Take the lower of the two readings recorded in paragraphs 4.54 and 4.55 and subtract the hybrid loss measured in paragraph 4.51. This value is the singing point (SP).

Example 3. Suppose the hybrid loss measured in paragraph 4.51 was 6.8 db open and 7.2 db shorted; the average hybrid loss is 7.0 db. Assume that the SP measured in paragraph 4.54 and 4.55 was 25 db and 27 db. The resultant SP is 25 (lower of two) - 7 = 18 db.

4.57 Alternate Method of Measuring SP: If the SPTS has enough gain to overcome the hybrid loss, it is more convenient to include this in the calibration. In doing this, the hybrid loss does not have to be subtracted for each measurement.

Example 4. The hybrid loss is 7 db. The oscillator is set for -7 dbm at 1000 Hz and applied to the SPTS (Figure 4B and 4C). With the gain dials set at zero, adjust the calibrate adjustment for zero dbm on the voltmeter. If the readings taken in paragraph 4.54 and 4.55 are 18 and 20 db, the SP would be 18 db (hybrid loss is accounted for in calibration).

4.58 Either method of measuring SP should yield identical results.

5. HOW TO MAKE IDLE CHANNEL NOISE MEASUREMENTS ON CARRIER CHANNELS

5.1 General

5.11 Idle channel noise measurements are relatively simple to make. Access to the carrier channel, seizure of the channel (signaling), and proper adjustment of the recorded data are the items that require attention. The noise measuring set (NMS) should have C-message weighting.

5.2 Access

5.21 At the measuring end, the carrier channel may be accessed at either the carrier two-wire drop (Figure 5A) or the carrier demodulator (Figure 5B). With proper adjustment of data (because of the difference of levels), measurements should yield the same results at both points. At the distant end, the channel should be accessed at the two-wire drop and terminated in 900 ohms(or 600 ohms at toll center) in series with 2 mfd. Make sure the central office equipment is disconnected at both ends.

5.3 Seizing the Channel

5.31 The carrier channel must be seized (at both ends) in its normal manner to place the channel in a normal operating (talking) condition. The method of seizure will depend on the type of signaling employed. Seizure of the channel will remove the signaling tone or shift it to another frequency.

5.32 E & M: To seize a channel with E & M signaling, simply apply -48 volts d.c. (fused) to each terminal "M" lead.

5.33 Outgoing Loop Dial: If the NMS has an internal holding coil (Northeast Electronics Corporation TTS 37B, etc.), simply switch the holding coil ON to seize the end with outgoing loop dial. If the NMS does not have an internal holding coil (Western Electric 3A, etc.), place a vf repeating coil in tandem with the NMS (Figure 2C). When the data is adjusted, the loss of the repeating coil should be added to the noise reading. When the outgoing loop dial end is to be terminated rather than measured, place a repeating coil in tandem with the termination or omit the 2 mfd blocking capacitor to seize that end. In the latter case, the resistor must be a "power" type to dissipate the heat developed.

5.34 Incoming Loop Dial: See paragraph 1.52.

5.35 Subscriber Carrier: On the subscriber end, use the technique described in paragraph 5.33 to seize that end. There is no seizure technique required for the CO terminal; access the two-wire drop as explained in paragraph 5.21.

5.4 Measurement

5.41 If the NMS has a calibration adjustment, calibrate as indicated. Set the NMS for 900 ohms (or 600 ohms at toll center or if measured at carrier demodulator), Noise Metallic (N_m), C-message weighted.

5.42 Measure the idle channel noise on each channel as shown in Figures 5A, 5B, or 5C as necessary and record data in dbrnc.

5.5 Data Adjustment

5.51 The data recorded in paragraph 5.42 (although it is valid data) has no real meaning until it is properly adjusted. Requirements for noise on a carrier channel are specified with reference to the sending end or a zero transmission level point. The noise is specified in terms of dbrnc-0, with the 0 being referenced to the sending end or zero transmission level point. If the channel is aligned for X db net loss, and the noise is read at the two-wire drop, X db must be added to the reading obtained in paragraph 5.42 to get dbrnc-0. However, if the noise were read at the carrier demodulator (Figure 5B), this is likely to be 7 db higher (+7 point) than the sending end. In this case, 7 db must be subtracted from the dbrnc reading to obtain dbrnc-0.

Example 1. The noise measured at the two-wire drop terminals of a carrier channel is 18 dbrnc (paragraph 5.42). The circuit is aligned for 3.0 db loss from drop to drop. The noise is 18 + 3 = 21 dbrnc-0.

Example 2. The same channel as in Example 1 was measured at the carrier demodulator and a reading of 28 dbrnc was obtained. This point is 7.0 db higher than the distant sending end, so the resultant noise is 28 - 7 = 21 dbrnc-0. This is identical with the adjusted noise of Example 1.

6. HOW TO MAKE IMPULSE NOISE MEASUREMENTS ON CARRIER CHANNELS

6.1 General

6.11 Impulse noise measurements are different from idle channel noise in that the instrument will not read continuous steady state noise. Instead, the impulse noise meter counts the number of transient high amplitude waves that exceed certain given values. Impulse noise criteria are becoming important factors in telephony as data is expected to be transmitted extensively in the future.

6.12 Because of the limited supply of instruments at this time to measure impulse noise, this procedure is written for the Northeast Electronics Corporation TTS 58A Impulse Noise Counter or equivalent. As other instruments become available, adjust the procedure to comply to the particular instrument used.

6.2 Access

6.21 At the measuring end, the carrier channel may be accessed at either the carrier two-wire drop (Figure 6A) or the carrier demodulator (Figure 6B). With proper adjustment of the impulse noise counter (because of difference of levels), measurements should yield the same results at both points. At

the distant end, the channel should be accessed at the two-wire drop and terminated in 900 ohms (or 600 ohms at toll center) in series with 2 mfd. Make sure the central office equipment is disconnected at both ends.

6.3 Seizing the Channel

6.31 The carrier channel must be seized (at both ends) in its normal manner to place the channel in a normal operating (talking) condition. The method of seizure will depend on the type of signaling employed. Seizure of the channel will remove the signaling tone or shift it to another frequency.

6.32 E & M: To seize a channel with E & M signaling, simply apply -48 volts d.c. (fused) to each terminal "M" lead.

6.33 Outgoing Loop Dial: With the impulse noise counter on the two-wire drop, switch the holding coil ON to seize the end with outgoing loop dial. When the outgoing loop dial end is to be terminated rather than measured, place a repeating coil in tandem with the termination or omit the 2 mfd blocking capacitor to seize that end. In the latter case, the resistor must be a "power" type to dissipate the heat developed.

6.34 Incoming Loop Dial: See paragraph 1.52.

6.35 Subscriber Carrier: On the subscriber end, use the technique described in paragraph 6.33 to seize that end. There is no seizure technique for the CO terminal.

6.4 Brief Description of TTS 58A

6.41 At the top of the instrument there is a BATTERY TEST, MONITOR jack, and three terminals to connect a special external filter.

6.42 First Row: There is a HOLD coil for seizing outgoing loop dial and subscriber carrier. Next is the input BRIDGING (external termination) or TERMINATING switch. Last is the POWER ON and OFF switch.

6.43 Second Row: First is the filter selection switch; this is usually set for VOICE weighting. Second is the MAIN REFERENCE LEVEL selector that is common to all three counters. Third is the input impedance selector which is usually 900 ohms for all cases except at toll centers and special purpose applications.

6.44 Third Row: This is the TIME selector and is generally set for 30 minutes.

6.45 Fourth Row: These are the A, B, and C REFERENCE LEVEL selectors for each of the three counters. This will be discussed in paragraph 6.48 below.

6.46 Fifth Row: The counters indicate the number of impulses or transient waves that exceed the reference level. The counters are set to zero by pressing down on the small levers at the bottom of each counter.

6.47 At the bottom there is a jack for powering the instrument from the 48-volt COE battery (there are also self contained batteries). Second is a jack for a dial or telephone. There is a choice of a 310 jack or binding posts to connect the instrument to the line or carrier drop.

6.48 Reference Level: The MAIN REFERENCE LEVEL varies the sensitivity of all counters in 10 db steps (0 to 70 db). Each counter can be individually adjusted in 2 db steps to a desired level of 0 to 20 db greater than the MAIN REFERENCE LEVEL. These are usually set at various levels called LO (A), MID (B), and HI (C). The A counter will count all impulses exceeding the reference level it is set for (addition of MAIN and A REFERENCE dials), but not exceeding the B counter setting. The B counter will count all impulses above its setting, but not exceeding the C setting. The C counter will count all impulses above its setting.

6.5 Measurement

i during the busy hour.

here data is adjusted after the measurements are taken, the
or Zero test point level (0 TPL) before measurements. If
rop, the REFERENCE LEVEL dials are reduced by the amount of
. The 1700 Hz loss may be determined as the average loss
e is measured at the demod of the carrier channel, set the
mpulse noise requirements (assuming the demod level is 7 db

6.53 The noise is measured in terms of X counts in Y minutes above Z reference level (at 0 TPL). One of the most common objectives at this time is for toll connecting trunks. For non-compandored trunks, one objective is no more than 90 counts in 30 minutes during the busy hour above 56 dbrn-0 reference level, voice weighted. For compandored trunks, an objective is no more than 90 counts in 30 minutes during the busy hour above 44 dbrn-0 reference level, voice weighted.

6.54 The TTS 58A has 3 counters. These can be set at the objective and also several db above and below the objective to get a "range" of the impulse noise. To measure impulse noise, connect the line terminals of the counter to the carrier two-wire drop, select the weighting (generally VOICE), select the TIME (generally 30 minutes), set the counters to 0 and the counter is set. (Figure 6A)

Example 1. A compandored trunk is aligned for 3.0 db net loss (and is also 3.0 db at 1700 and 2300 Hz) and is being checked to see if it meets impulse noise objectives. The objectives are no more than 90 counts in 30 minutes during the busy hour above 44 dbrn-0, voice weighted. This would make the reference level 44 - 3 (net loss) = 41 db. The MAIN REFERENCE LEVEL is set for 30 and B is set for 10 (30 + 10 = 40 which is just below the 41 required). To check the impulses 6 db above and below the requirement, A is set for 4 (34) and C for 16 (46). The filter is set for VOICE weighting, time for 30 minutes and (last) the counters are set for 0. After 30 minutes, A = 431, B = 130, and C = 74. This means that there were 130 + 74 (B + C) = 204 counts that exceeded the 44 dbrn-0 (actually 43) level objective. This circuit will not meet the specified data objectives.

7. HOW TO MAKE PULSE SIGNALING MEASUREMENTS ON CARRIER CHANNELS

7.1 General

7.11 Some trunk carrier terminals are equipped with E & M signaling at both ends or loop dial signaling at both ends. Other terminals are equipped with E & M at one end and loop dial at the other.

7.12 E & M: Carrier terminals employing E & M signaling at both ends are generally two-way trunks and usually must be checked in both directions.

7.13 Loop Dial: If both carrier terminals have loop dial signaling, one end is outgoing loop dial (sending end) and the other is incoming loop dial (receiving end) for signaling in one direction only. Two-way loop dial signaling is not usually found on carrier trunks.

7.14 E & M and Loop Dial: This combination consists of outgoing loop dial signaling at one end and E & M signaling at the receiving end. This restricts signaling to one direction only.

7.15 Subscriber Carrier: Subscriber carrier can only be dialed one way: from the subscriber terminal to the CO terminal. In checking pulsing, it is the same as one-way loop dial signaling on trunks.

7.2 Access

7.21 E & M: At the sending end, access the carrier "M" lead and at the receiving end, access the carrier "E" lead. These points must be disconnected from the COE.

7.22 Loop-Dial and Subscriber Carrier: Access the two-wire drop for sending and receiving pulses.

7.3 Measurement

7.31 The pulsing test set must be capable of generating and receiving pulses over a range of 8 to 12 pps and at least 30 to 70 percent break. The test set should be equipped to measure both E & M and loop dial signaling. The received pulses must be read across "dry" contacts (no spark suppressors, etc.), or a slave relay must be used. The slave relay is a low impedance, fast switching relay and is usually built into test sets adapted to loop types of signaling, including subscriber carrier channels.

7.32 E & M Send: With the test set adjusted for E & M signaling (toward line), calibrate and send 60 percent break at 10 pps on the "M" lead as shown in Figure 7A. Also send at other percent break and speeds as required by the carrier multiplex specification. Where inband signaling is used, special attention should be given to the pulsing limits of the signaling units under test.

7.33 Loop Dial and Subscriber Carrier-Send: With the test set adjusted for loop signaling, calibrate and send 60 percent break at 10 pps and apply to two-wire drop under the following three conditions: (1) direct from the pulser (Figure 7B); (2) through loop (Figure 7C); and (3) through "A" leak (Figure 7D). Loop and "A" leak are described below.

7.34 E & M Receive: Adjust the test set for E & M signaling (toward line). With an off-hook at the distant end, calibrate the test set (Figure 7E). With pulses sent from the distant end, read the received percent break. Where inband signaling is used, special attention should be given to the pulsing limits of the signaling units under test.

7.35 Loop Dial and Subscriber Carrier Receive: Adjust the test set for loop signaling. A slave relay must be used for loop dial and may be required for subscriber carrier. With an off-hook at the distant end, calibrate the test set (Figure 7A). With pulses sent from the distant end, read the received percent break.

7.4 Loop and "A" Leak Tests as Applied to Loop Dial Signaling:

7.41 The loop network (Figure 7G) represents the longest loop resistance that the carrier signaling is likely to encounter. For loop dial signaling, this is 1900 ohms; for subscriber carrier, it is the manufacturer's specified loop resistance limit.

7.42 The "A" leak network (Figure 7H) represents 10 ringers bridged on a zero loop with high leakage.

7.43 Loop and "A" leak tests are to test the carrier signaling under limiting conditions. Pulses sent at 60 percent break at 10 pps through the loop and "A" leak networks with zero loop must be received within the range of 30 to 70 percent break.

8. HOW TO MAKE INSERTION LOSS MEASUREMENTS AT CARRIER FREQUENCIES

8.1 Insertion Loss of Open Wire

8.11 Before making insertion loss measurements, it is a good practice to connect the Frequency Selective Voltmeter (FSVM) to the open wire line and sweep the frequency range of interest. This is to determine if there are any "foreign" signals that may interfere with the measurements and, later, the carrier system to be used. Any signals stronger than -60 dbm should be recorded. It is also a good practice to monitor the FSVM with headphones to determine the nature of the interfering signals.

8.12 The oscillator should be calibrated for zero dbm or other convenient level as shown in Figure 8A; this calibration includes the loss of the coils at the sending and receiving ends (approximately 0.2 db per coil). The repeating coil ratio for open wire is 600:600 ohms.

8.13 Connect the oscillator (through one of coil) to the open wire line as shown in Figure 8B. Also connect the FSVM on the receiving (distant) end as shown.

8.14 Record the sending level of the oscillator and the receiving level on the FSVM. The insertion loss is the difference of the two levels.

Example 1. Oscillator is calibrated for a sending level of +10 dbm. The FSVM is receiving -14 dbm. The difference of the two readings is: +10 - (-14) = 24 db; thus, the insertion loss is 24 db.

8.15 This process should be repeated for a number of frequencies throughout the range of interest.

Example 2. If the carrier is to be applied to the line at frequencies from 40 kHz to 180 kHz, a good check of the line would be to measure the insertion loss at 40 kHz, 60 kHz, 80 kHz, etc., through at least 200 kHz.

8.16 In measuring open wire lines, especially note the presence of absorption peaks so those frequencies may be avoided in applying carrier.

8.17 The above procedure has assumed that only open wire is used and that there is little or no entrance cable involved. A more practical situation would involve entrance cable and open wire. A good rule of thumb is to impedance match the cable-open wire junction if there is more than 50 feet of entrance cable. The impedance matching device may be a carrier frequency repeating coil for measuring purposes; however, on carrier systems this is usually an autoformer that matches both voice and carrier frequencies at the junction and provides a d.c. path to subscribers on the physical circuit. It is desirable that the type of impedance matching device that will be used on the installed system also be used when making the insertion loss measurements.

8.18 The oscillator may be calibrated as shown in Figure 8A or Figure 9A (whichever is more convenient) and measured as shown in Figure 8C.

8.2 Insertion Loss of Cable

8.21 Because cable is shielded, it is less susceptible to "foreign" signals. In practice, most cable leads have unshielded RDW and open wire taps at the ends of the cable pairs. These RDW and open wire taps can be on pairs other than those to be used for carrier and still couple "foreign" signals into the shielded cable pair intended for carrier. Because of the high loss of cable (compared to open wire), it may possibly be necessary to connect a FSVM and sweep the frequency range of interest not only at the central office, but also at junctions or at the end of the pair where adjacent circuits have unshielded pairs.

8.22 The oscillator should be calibrated as shown in Figure 9A and measured as shown in Figure 9B. The only significant change in measuring cable as compared to open wire is the characteristic impedance. The repeating coils are now set at 600:135 ohm ratio. Cable will not exhibit absorption peaks in the carrier frequency range.

9. HOW TO MAKE CARRIER FREQUENCY CROSSTALK LOSS MEASUREMENTS ON OPEN WIRE AND CABLE

9.1 General

9.11 This procedure for measuring crosstalk loss is based on the assumption that there is an open wire or cable system already installed and in use, and the time has come that two or more carrier systems are needed on one route. The procedure deals with measuring far-end equal-level crosstalk loss between two pairs; this is generally the controlling factor in applying carrier channels of the same frequency to separate pairs on the same route.

9.12 It is assumed that the pairs measured meet insertion loss requirements and that crosstalk loss is the only concern.

9.2 Selection of Pairs

9.21 There are two major factors that affect crosstalk. These are similarity and separation. For two given pairs, the more the pairs are separated and the more dissimilar twist lengths and other geometry of layup, the better (higher) the crosstalk loss.

9.22 Selecting open wire pairs should not be difficult. On a 10-pin crossarm, the pairs are numbered: pins 1-2 = pair 1; pins 3-4 = pair 2, etc. In R-1, REA-1, and other transposition systems, pins 1-2, 5-6, and 9-10 are similarily transposed and also 3-4 is similar to 7-8. The best pair combinations to apply two systems of carrier under these circumstances would be 1-2 and 7-8 or 3-4 and 9-10.

9.23 Crosstalk is less of a problem on cable. There should be many pair combinations that have excellent crosstalk loss characteristics. This is because cable is made in layers, units, etc., and the pairs have various twist lengths. However, when carrier is used on cable, it is often applied to older cable which may not meet present cable crosstalk loss requirements.

9.24 Carrier manufacturers often need to be assured that certain crosstalk loss requirements are met to guarantee performance of their systems. Crosstalk data is also used to determine if compandors are needed with the carrier.

9.3 Crosstalk Loss Measurements on Open Wire

9.31 After selecting the open wire pairs to be measured, disconnect all equipment, taps, drops, etc., from both pairs for the entire length that the two systems will parallel each other. There is no need to disturb the other pairs on the line.

9.32 Set the oscillator for a level of from 0 to +20 dbm (no exact calibration necessary). Connect the oscillator to the disturbing pair as shown in Figure 10A. At the distant end, connect the selective frequency voltmeter (FSVM) to the disturbing pair and record the reading (tune for maximum signal). Then connect the FSVM to the disturbed pair (Figure 10B) and again record the reading. The far-end equal-level crosstalk loss is the difference of the two readings.

Example 1. The oscillator was set for approximately +10 dbm and applied to pair A. At the distant end, the FSVM (connected to pair A) is tuned and reads -9.3 dbm. On pair B, the FSVM reads -55.7 dbm. The far-end equal-level crosstalk loss is -9.3 - (-55.7) = 46.4 db.

9.33 The crosstalk loss should be measured at as many frequencies as necessary to insure against crosstalk problems. If the first pair combination checked does not meet the requirements, check another pair combination.

9.4 Crosstalk Loss Measurements on Cable

9.41 Crosstalk loss measurements on cable are different from those on open wire in several respects.

9.42 Because of the high insertion losses on cable pairs, the measurements are taken in "sections." A "section" may be the distance between repeaters or any other convenient length short enough to obtain valid measurements.

9.43 Both insertion losses and crosstalk losses (as a function of frequency) are far more predictable on cable than on open wire. Therefore, crosstalk loss is generally measured at only one frequency. (REA crosstalk loss requirements are specified at 150 kHz.)

9.44 Though the measuring length is not generally specified, crosstalk loss requirements are usually specified for a given length. This correction factor for length is discussed later.

9.45 After selecting the cable pairs to be measured, disconnect all equipment, taps, drops, etc., from both pairs for the entire measuring length. There is no need to disturb the other pairs that are in service. The pairs that are neither in service nor to be measured may be left "floating," or may be bunched and grounded at one end only.

9.46 Set the oscillator for the required frequency and at a level of from 0 to +20 dbm (no exact calibration necessary). Connect the oscillator to the disturbing pair as shown in Figure 11A. At the distant end, connect the FSVM to the disturbing pair and record the reading (tune for maximum signal). Then connect the FSVM to the disturbed pair (Figure 11B) and again record the reading. The far-end equal-level crosstalk loss is the difference of the two readings (for that length and frequency).

9.5 Crosstalk Loss Correction Factors

9.51 REA crosstalk loss requirement for cable is 73 db RMS at 150 kHz for all combinations of adjacent, alternate, and center to first layer pairs per 1000 feet. For lengths other than 1000 feet, the crosstalk loss requirement (in db) is adjusted by subtracting: $10 \log_{10} \frac{\text{length in feet}}{1000}$.

9.52 In order to find out if certain cable pairs can meet carrier manufacturers' requirements for crosstalk loss, the data may be adjusted for length by using the formula in paragraph 9.51. However, it should be kept in mind that to check a cable for specification, all adjacent, alternate, and center to first layer pair combinations must be measured.

Example 2. Carrier is to be applied to a cable route containing mostly new cable of good quality. However, two miles of this cable (one repeater section) is 10 years old and the crosstalk is in doubt. The carrier manufacturer states that if the crosstalk loss for that section is 73 db per 1000 feet or better at 150 kHz between pairs, the system will not need compandors. The compandor costs make it worthwhile to measure the crosstalk on that section of cable. The measured crosstalk at 150 kHz between pairs A and B was 64 db for the two miles. Applying the correction in paragraph 9.51, the crosstalk requirement for the two miles is $73-10 \log_{10} \frac{10,560}{1000} = 73-10.2 = \underline{62.8 \text{ db}}$. The measured crosstalk loss of 64 db meets the requirement for that pair combination.

9.53 Crosstalk loss is generally measured on lengths longer than 1000 feet. The following Table gives the correction (in db) for some lengths. When applying these corrections to the crosstalk loss requirements at 1000 feet, subtract the correction from the requirement.

Crosstalk Loss Requirement Corrections

Length	Correction	Length	Correction
2000 ft.	3.0 db	7000 ft.	8.5 db
3000 ft.	4.8 db	8000 ft.	9.0 db
4000 ft.	6.0 db	9000 ft.	9.6 db
5000 ft.	7.0 db	10000 ft.	10.0 db
6000 ft.	7.8 db	11000 ft.	10.4 db

9.54 Sometimes it is necessary to use crosstalk loss requirements and data measured at 150 kHz to predict the crosstalk loss at higher frequencies. For frequencies higher than 150 kHz, correct by subtracting $20 \log_{10} \frac{\text{kHz}}{150}$. This formula provides a high degree of accuracy for correcting crosstalk loss measurements. The following Table gives the correction (in db) for frequencies higher than 150 kHz.

Crosstalk Loss Corrections Versus Frequency

Frequency	Correction	Frequency	Correction
200 kHz	2.5 db	350 kHz	7.4 db
250 kHz	4.5 db	400 kHz	8.5 db
300 kHz	6.0 db	450 kHz	9.6 db

APPENDIX A

TERMINOLOGY AS APPLIED TO CARRIER MULTIPLEX MEASUREMENTS

The following definitions or descriptions of certain terms used in the test of this section are provided as information for the reader who is not familar with this terminology. The definitions relate particularly to carrier multiplex measurements and are not intended to apply to all uses of the terms.

1. Return Loss: This is a term used to describe the similarity between two impedances. A hybrid is used to compare two impedances and the difference between the applied signal and the returned signal is called return loss.

2. Echo Return Loss (ERL): This is the composite return loss over the echo range when the two wire voice frequency impedance of a carrier channel is compared to a standard impedance such as 600 ohms in series with 2 mf. The echo range is considered to be 500 to 2500 Hz.

3. Singing Point (SP): This is approximately the lowest value of return loss between a standard impedance and the input impedance of the two wire voice drop of a carrier channel within a specified frequency range. (1)This specified frequency range is generally that of the intertoll carrier, not the carrier channel being measured. (2)This is a measure of return loss, not to be confused with singing of the channel being measured.

4. db: The abbreviation for decibels and is used to express the ratio of two voltages, currents or powers.

5. dbm: The abbreviation for decibels above or below one milliwatt. A unit used to express a level of power referred to one milliwatt.

6. dbrnc: This is a measure of noise power. The noise is weighted by passing it through a special filter which simulates characteristics of the 500 type telephone set and the human ear. Zero dbm at 1000 Hz = 90 dbrnc. This measurement is useful in determining noise criteria as it affects telephone transmission.

7. Inband Signaling: A method of signaling which uses tones within the voice frequency passband of the carrier multiplex.

8. Out-of-Band Signaling: A method of signaling which uses tones outside of the voice frequency passband of the carrier multiplex.

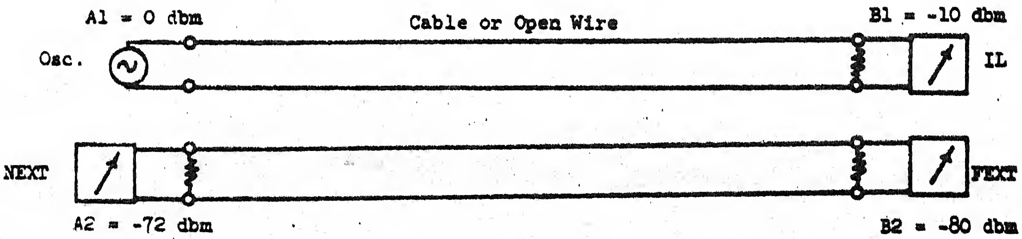
9. Crosstalk Loss: This can be best explained by the use of a simple diagram using a hypothetical example.

   (1) Referring to the diagram below, the A1 oscillator sends at a level of zero dbm.

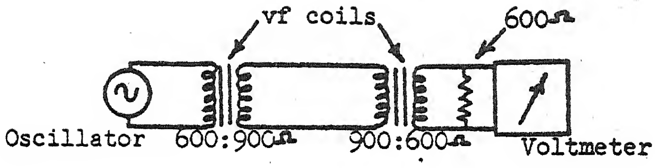
   (2) The B1 voltmeter receives the signal at -10 dbm; 10 db is the insertion loss of the pair.

   (3) The B2 voltmeter receives the signal on another pair at -80 dbm due to coupling between the pairs; the far end crosstalk loss (FEXT) is -10 -(-80) = 70 db.

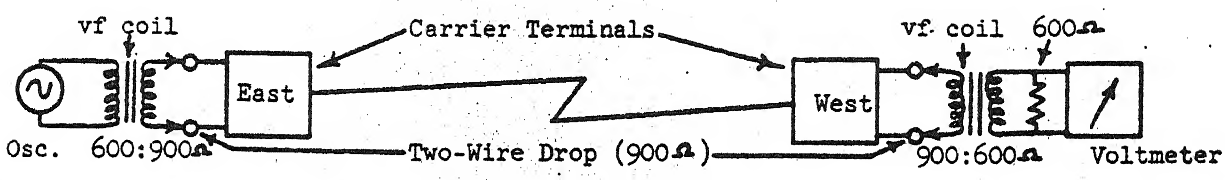
   (4) The A2 voltmeter receives the signal due to coupling at -72 dbm; the near end crosstalk loss (NEXT) is 0 - (-72) = 72 db.



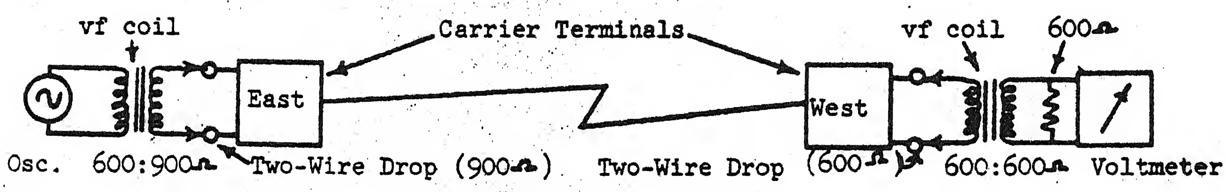
Note: The oscillator impedance and the voltmeter terminating impedances are near that of the cable or open wire characteristic impedance.



A. CALIBRATE



B. MEASURE: BOTH TERMINALS 900 OHMS



C. MEASURE: ONE TERMINAL 900 OHMS, ONE 600 OHMS

FIGURE 1

VOICE FREQUENCY INSERTION LOSS MEASUREMENTS ON CARRIER CHANNELS

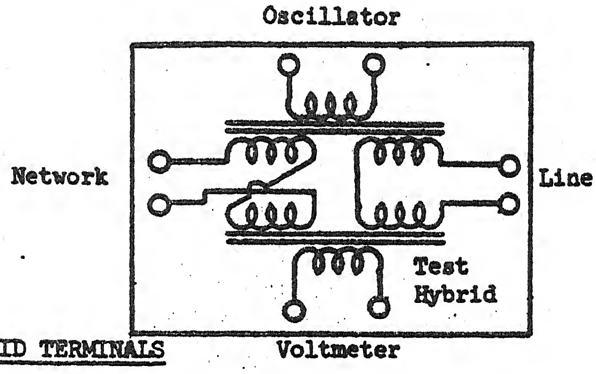
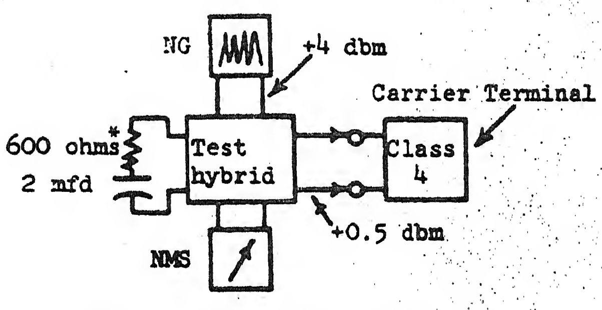
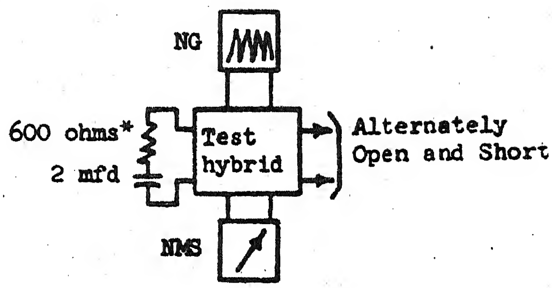


FIGURE 2

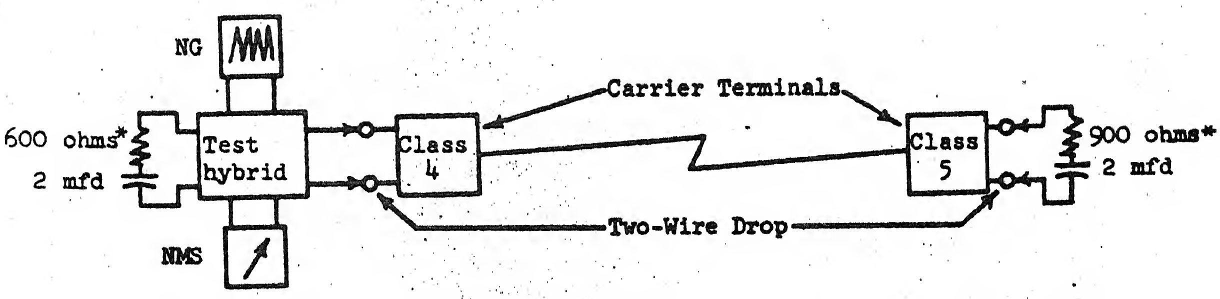
DRAWING OF TEST HYBRID TERMINALS



A. PRELIMINARY CALIBRATION



B. ERL REFERENCE



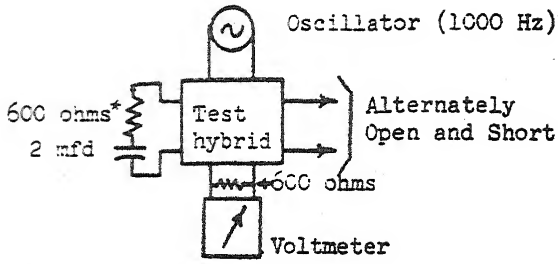
C. ERL MEASURE

Note: The Noise Generator (NG) is set for 455B weighting. The Noise Measuring Set (NMS) is set for 600 ohm Noise Metallic, C-Message Weighted.

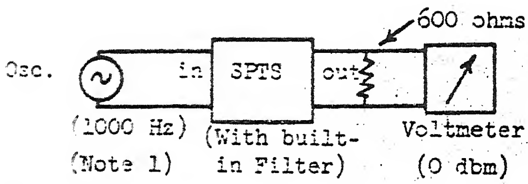
*This impedance depends on the class of office; 600 ohms for Class 4 and 900 ohms for Class 5.

FIGURE 3

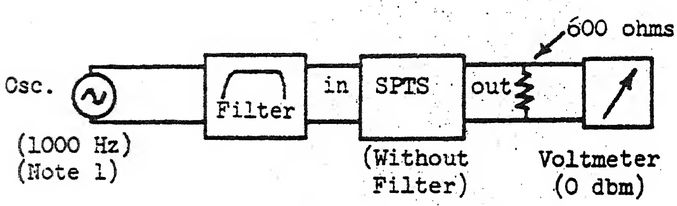
ECHO RETURN LOSS MEASUREMENT ON CARRIER CHANNELS



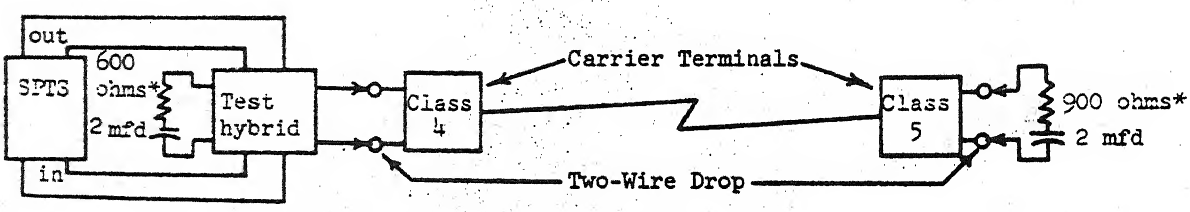
A. TEST HYBRID LOSS



B. SPTS CALIBRATE



C. SPTS CALIBRATE



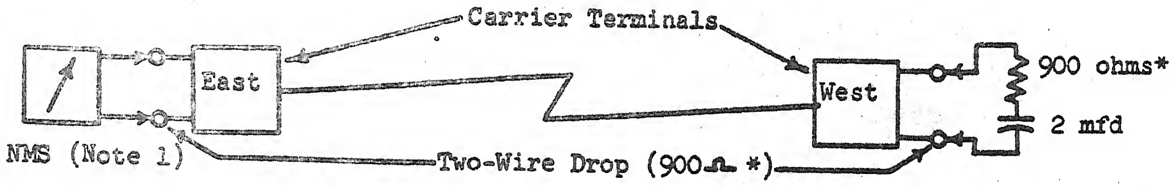
D. SP MEASURE

Note 1: The oscillator level is zero dbm except for the Alternate Method of Measuring SP discussed in paragraph 4.57.

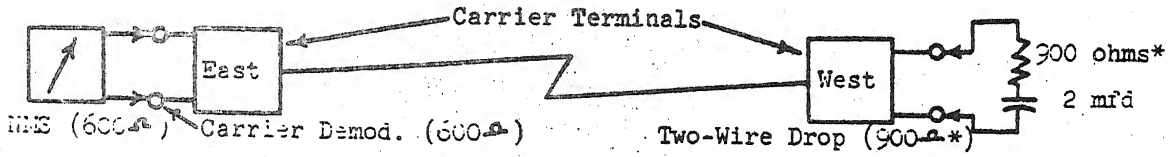
*This impedance depends on the class of office; 600 ohms for Class 4 and 900 ohms for Class 5.

FIGURE 4

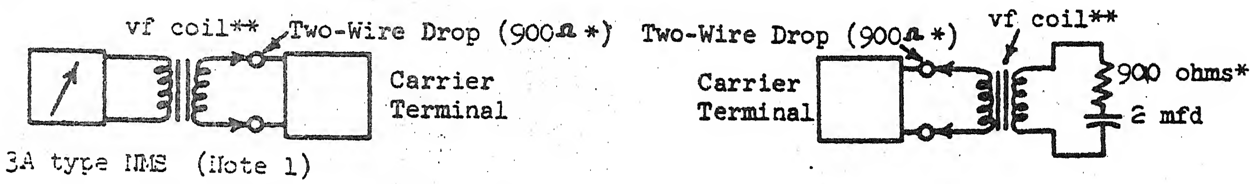
SINGING POINT MEASUREMENTS ON CARRIER CHANNELS



A. MEASURED AT TWO-WIRE DROP



B. MEASURED AT CARRIER DEMODULATOR



C. SEIZURE OF OUTGOING LOOP DIAL TERMINALS

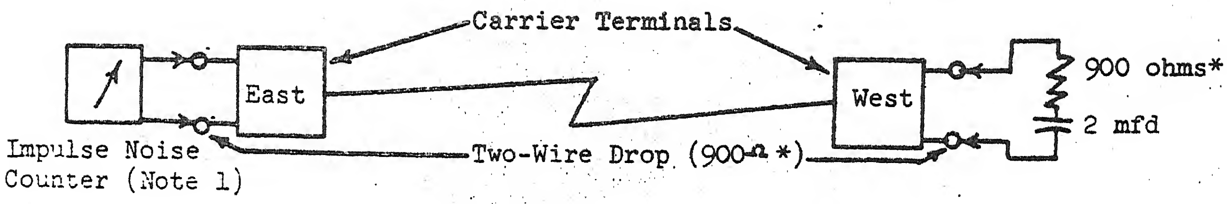
Note 1: Noise Measuring Set (NMS) is set for 900 ohms*, Noise Metallic (Nm), C-message weighted.

*If the office is a toll center (Class 4) or measured at the carrier demodulator (Figure 5B), the impedance is 600 ohms. In all other cases the impedance should be 900 ohms.

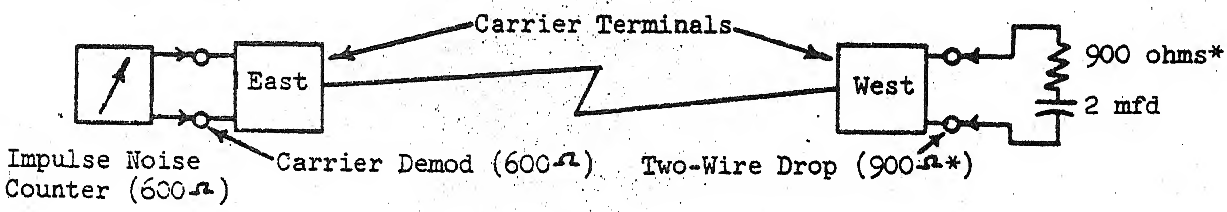
**Coils are set for 1:1 ratio which may be called 600:600 or 900:900 ohms.

FIGURE 5

IDLE CHANNEL NOISE MEASUREMENTS ON CARRIER CHANNELS



A. MEASURED AT TWO-WIRE DROP



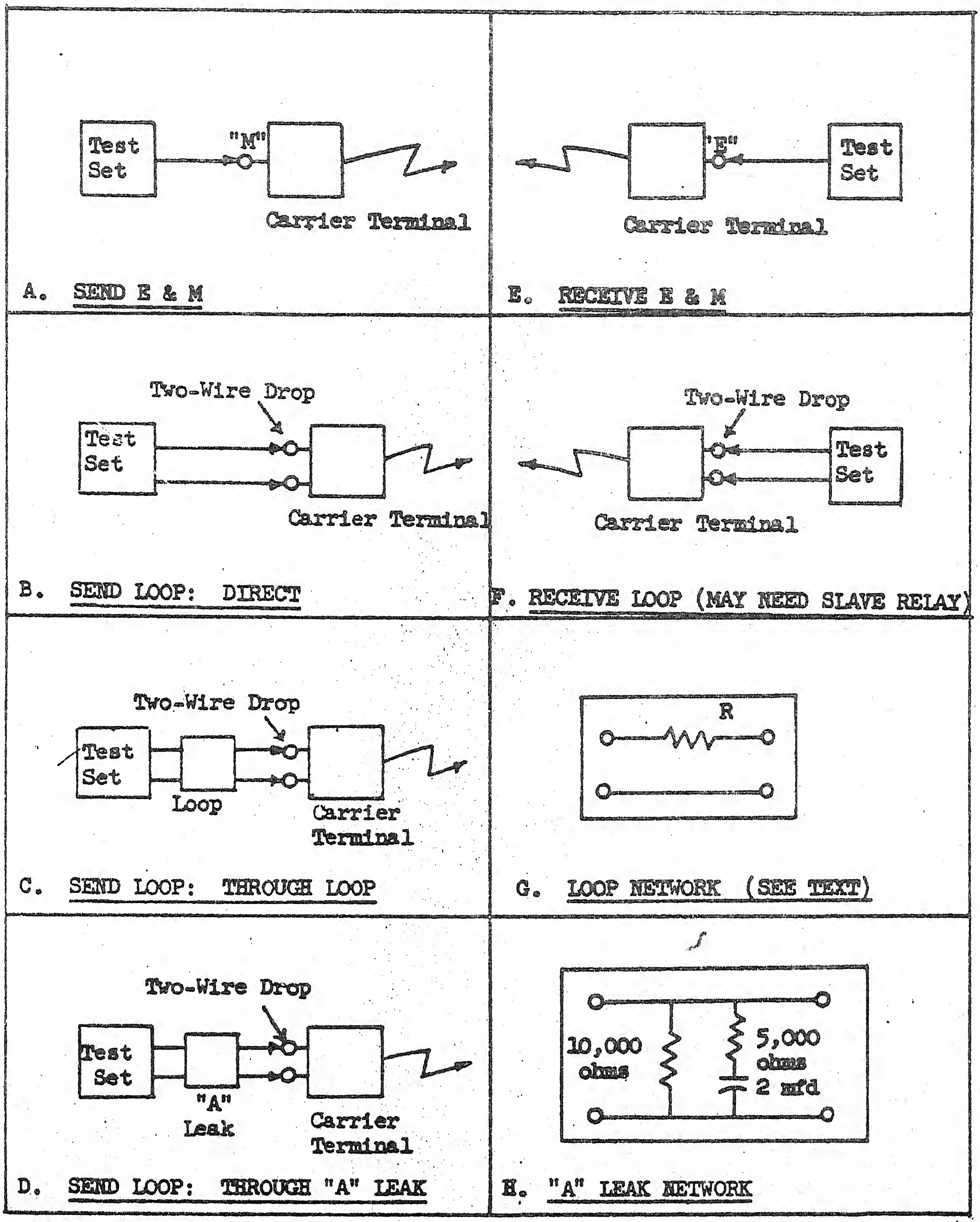
B. MEASURED AT CARRIER DEMODULATOR

Note 1: Impulse Noise Counter is set for 900 ohms except for toll center or special purpose application. See text for other settings.

*Use 600 ohms if this is a toll center.

FIGURE 6

IMPULSE NOISE MEASUREMENTS ON CARRIER CHANNELS



A. SEND E & M

E. RECEIVE E & M

B. SEND LOOP: DIRECT

F. RECEIVE LOOP (MAY NEED SLAVE RELAY)

C. SEND LOOP: THROUGH LOOP

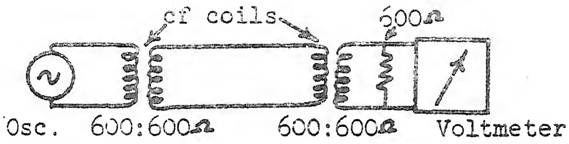
G. LOOP NETWORK (SEE TEXT)

D. SEND LOOP: THROUGH "A" LEAK

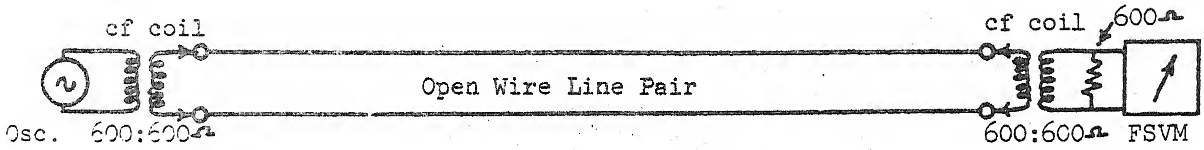
H. "A" LEAK NETWORK

FIGURE 7

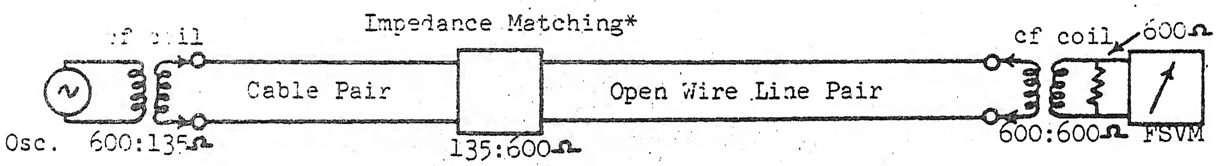
PULSE SIGNALING MEASUREMENTS ON CARRIER CHANNELS



A. CALIBRATE



B. MEASURE

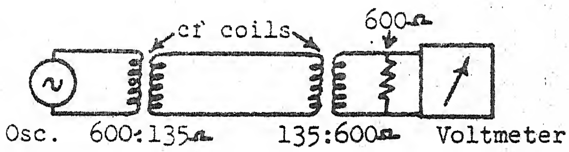


C. MEASURE: MORE THAN 50 FEET OF ENTRANCE CABLE

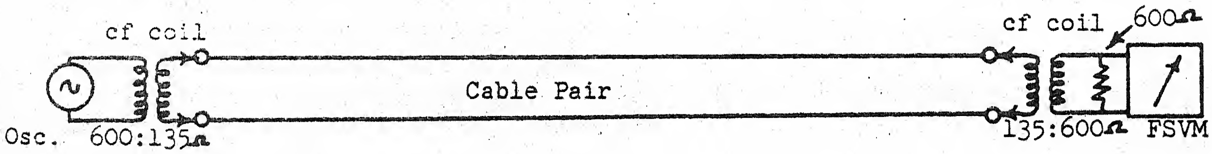
*This may be a repeating coil or other impedance matching device (see paragraph 8.17).

FIGURE 8

CARRIER FREQUENCY INSERTION LOSS ON OPEN WIRE



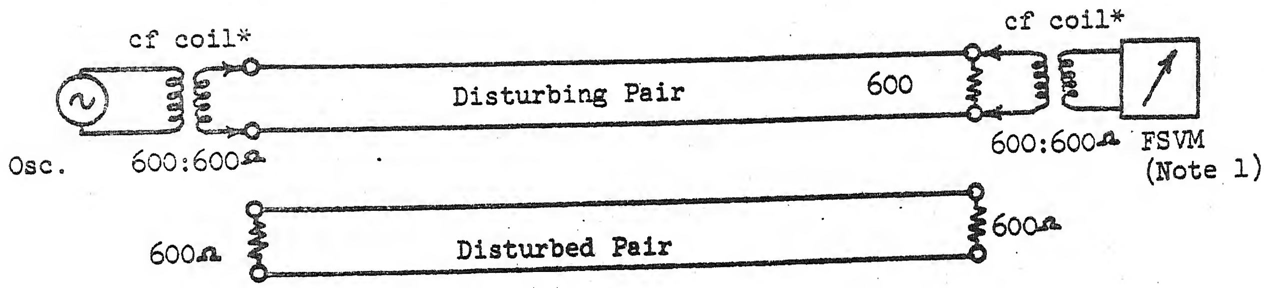
A. CALIBRATE



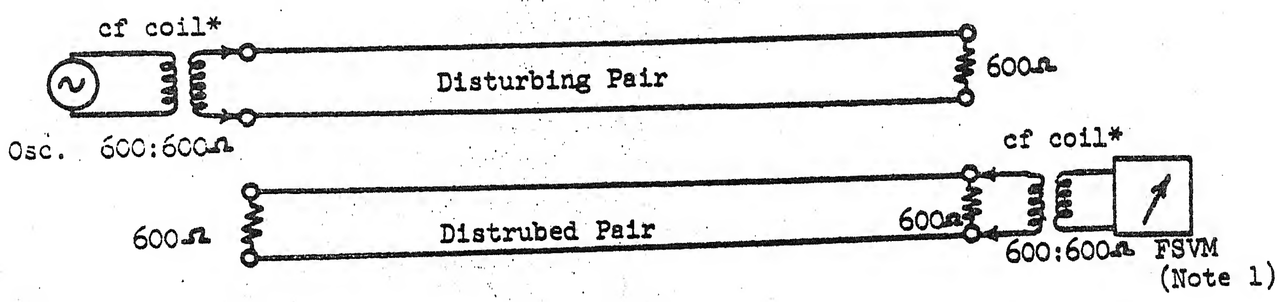
B. MEASURE

FIGURE 9

CARRIER FREQUENCY INSERTION LOSS ON CABLE



A. REFERENCE



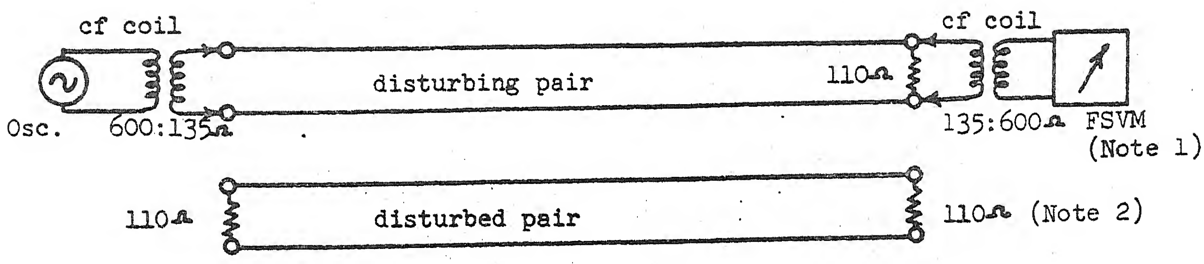
B. MEASURE

Note 1: The FSVM input is set in the 600 ohm bridging position.

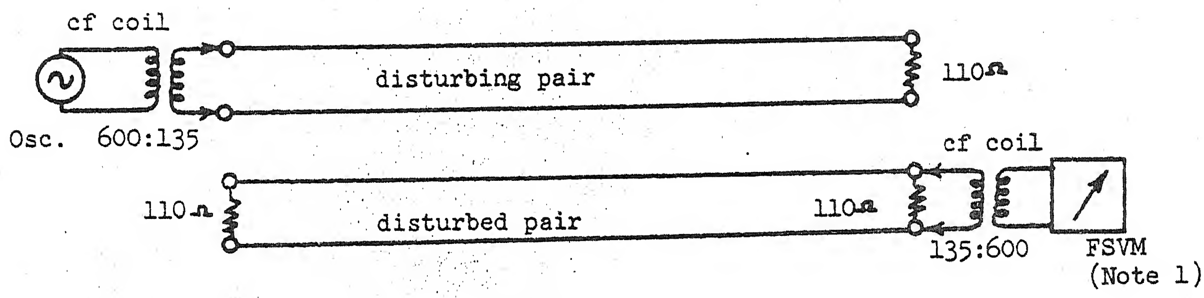
*The cf coils may be omitted if the oscillator and FSVM have well balanced output and input terminals and are of the proper impedance.

FIGURE 10

CARRIER FREQUENCY CROSSTALK LOSS MEASUREMENTS ON OPEN WIRE



A. <u>REFERENCE</u>



B. <u>MEASURE</u>

Note 1: The FSVM input is set in the 600 ohm bridging position. For the cable crosstalk measurements, the cf coil may be omitted if the input can be set in the 135 ohm bridging position.

Note 2: The proper termination for cable having a mutual capacitance of 0.083 mfd per mile is 110 ohms. If this is not available 135 ohms may be used with a high degree of accuracy.

<u>FIGURE 11</u>

<u>CARRIER FREQUENCY CROSSTALK LOSS MEASUREMENTS ON CABLE</u>